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MICROBROTULA RANDALLI, A NEW VIVIPAROUS
OPHIDIROID FISH FROM SAMOA AND NEW HEBRIDES,
WHOSE EMBRYOS BEAR TROPHOTAENIAE

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The objectives of this paper are: to diagnose the viviparous ophidioid fish genus *Microbrotula* Gosline; to describe an heretofore unknown species of the genus from Samoa and New Hebrides; to record in this species the second known occurrence of trophotaeniae in ophidioid fishes; and to discuss the possible significance of trophotaeniae.

Microbrotula (Gosline, 1953) was described for two species from Oahu, Hawaii: *rubra* (type-species) and *nigra* (subsequently referred to *Oligopus* Risso, where it is a homonym and renamed *Oligopus waikiki* by Cohen, 1964). Gosline's description of *M. rubra* was based on six specimens, of which three have been available for study.

One of the four Samoan *Microbrotula* is a gravid female, and upon examining embryos we discovered that they carried trophotaeniae, structures found in the embryos of several other species of viviparous fishes. We describe them in some detail.

Microbrotula Gosline

Diagnosis: Chin barbels absent. Gill membranes free from each other and from isthmus. Live-bearing; no ossified parts in male intromittent organ. Ventral fins immediately adjacent to each other, each with a single ray originating well behind symphysis of cleithra, a distance equal to approximately two-thirds snout length or more; pelvic girdle not extending anteriorly to symphysis of cleithra. Vertical fins confluent, covered with thin skin through which fin rays easily visible.

Pectoral fin entire, without separate elongated rays; pectoral peduncle not greatly elongated, broader than long. Caudal fin rays 4 to 6. Body relatively short, depth 5.3–6.4 in standard length, completely covered with small imbricate scales. Lateral line in the form of free papillae. Head partly naked. Eyes developed but small, more than 6 times in head length. Snout depressed. Anterior nostril tubular, located directly above upper lip. Spine on opercle sharp and needle-like. Maxillary expanded posteriorly, not sheathed, with a small ventrally-directed process near postero-ventral angle. Tongue with an anterior, prow-like extension. Developed gill rakers on first arch 3 or 4. Branchiostegal rays 7. Teeth not all tiny and granular, some enlarged, present on pre-maxillary, vomer, palatine and dentary; no median basibranchial tooth patch; paired tooth patches at the base of gill arches 3 and 5.

First neural spine short, neural spines 4 to 7 depressed. Ribs absent on first centrum. Abdominal vertebrae 11 or 12; total vertebrae 51 to 56. Parietals separated by supraoccipital.

Discussion: *Microbrotula* appears to more closely resemble *Calamopteryx* than any other known ophidioid genus, as noted by Böhlke and Cohen (1966). Most importantly, both genera contain small viviparous species with imbricate scales on the body, confluent vertical fins, a single ray in each ventral fin, no ossified parts in the male intromittent organ, and 7 branchiostegal rays.

Several important distinguishing characters are (*Microbrotula* first followed by *Calamopteryx* in parenthesis): pectoral peduncle and radials normal—the three specimens of *M. rubra* that we have examined do not resemble the figure given by Gosline (1953, fig. 1c) for this character (greatly elongate); first ribs on centrum 2 (on centrum 1); lower angle of preopercle lacking a curved, anteriorly-directed spine (spine present); spine on opercle sharp and needle-like (flattened and flap-like); dorsal fin rays 81 to 88 (58 to 70); anal fin rays 71 to 76 (40 to 57); caudal fin rays 4 to 6 (8 to 10); vertebrae 51 to 56 (37 to 46).

Calamopteryx was not yet known when Gosline (1953) described *Microbrotula*. He stated that, "*Microbrotula* seems to be a dwarfed, shallow-water offshoot of a *Catactyx*-like fish" a suggestion with which we concur and which would apply to *Calamopteryx* as well.

The two known species of *Microbrotula* may be distinguished by means of the characters presented in Table 1.

Microbrotula randalli, new species

Figure 1

Description: See Table 2 for counts and measurements. Body compressed, relatively short for an ophidioid, tail end of body pointed but not attenuate.

Postorbital part of head about as deep as broad. Snout depressed, broadly rounded in dorsal view. Jaws subequal but fleshy snout pro-

TABLE 1. Diagnostic characters for two species of *Microbrotula*.

Character	<i>randalli</i>	<i>rubra</i>
Pores on top of head	5; 1 median in rear of interorbital area, 1 each near antero- and postero-dorsal segments of each eye	none
Pectoral fin rays	11	13-14*
Vertebrae	53-56	51-52
Orbit diameter into head length (hl)	6.4-8.4	11.0-15.4
Interorbital width into hl	10.7-13.7	3.6-4.2
Snout length into hl	5.4-6.2	4.0-5.2
Predorsal distance into SL	2.4-2.5	2.1-2.3

* Gosline (1953) gives 12-14.

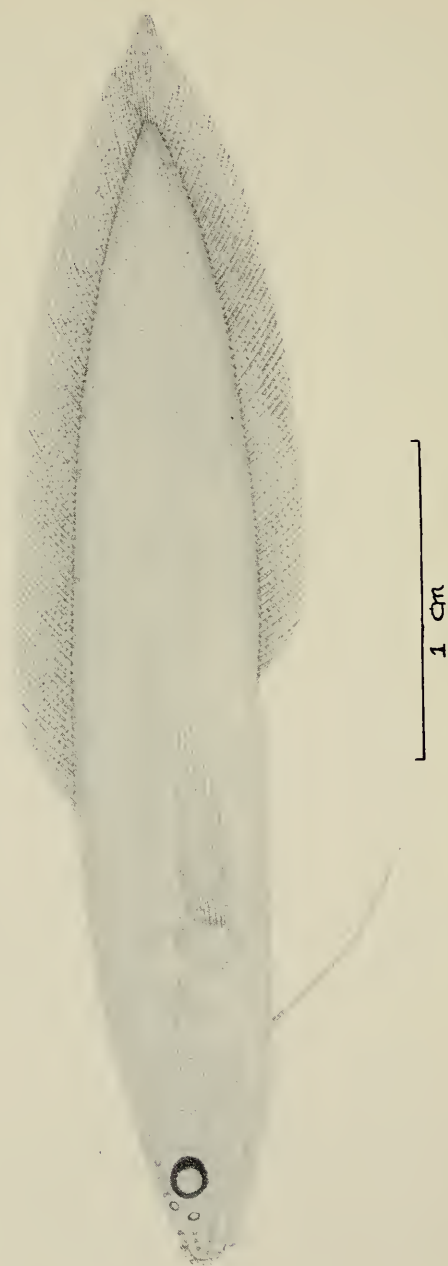


FIG. 1. *Microbrotula randalli*, paratype, USNM 214112, ♀, 35.8 mm SL.

jecting beyond jawbones. Orbit elliptical; eyes directed antero-laterally. A spectacle, which covers the orbit, transparent over the protruding lens, translucent elsewhere. Anterior nostril a tissue thin tube projecting directly over upper lip; posterior nostril a prominent pore in front of mid-level of orbit. Dorsal rim of maxillary sheathed for most of its length but expanded postorbital section free.

Minute, unpigmented papillae sparsely distributed on head, most abundant on snout. Indistinct ridges and flaps on snout, most obvious at tip of upper jaw. Sensory pores present along mandibular, lateral, infra-orbital and supra-orbital canals; precise enumeration is not possible. The most obvious pores are 5 on the surface of head: 1 each at the antero and postero-dorsal segments of each orbit, and a median one at the rear of interorbital region.

Gill rakers on first arch in the form of 2 or 3 flat spiny pads on the upper arm, a compressed spiny raker at the angle, preceded on the lower arm by a pad, a compressed triangular raker, a pad, a triangular raker, and 5 or 6 pads. The two developed rakers on lower arm anteriorly depressed so that their rear spiny faces are dorsally directed.

Premaxillary dentition consists of a row several teeth wide of minute granular teeth; at anterior end of the premaxillary, anterior to the vomer, the row is broader and in addition to small teeth also 5 to 10 longer sharp pointed needle-like teeth. Vomerine teeth in a tuft on each side of head of bone, grading from tiny and granular to larger and needle-like. Palatine with a long narrow band of teeth similar to those on the vomer, the largest farther anterior. The dentary bears a broad band of small, closely packed granular teeth and along the medial edge of the band a widely spaced row of 12 to 15 longer needle-like teeth.

Fin rays slender and filamentous, membrane connecting rays of median fins clear to slightly translucent, rays free distally. Pectoral fin on a broad fleshy pad, fin extending about two-thirds of distance from the pectoral base to the vent. Ventral fins immediately adjacent to each other and located well behind symphysis of cleithra. Caudal fin rays exerted.

Body scales imbricate, small, transparent and cycloid. Scales imbricate to non-overlapping on the head, several present over dorsal area of spectacle and on expanded rear part of maxillary; snout and tip of lower jaw naked.

Color in alcohol pale straw. Small, widely spaced, brown chromatophores present behind eye and to a greater or lesser extent on cheek and along side of body. Peritoneum pale. Live color salmon pink (based on notes by Randall and a color transparency).

The single male specimen has a triangular, fleshy hood immediately posterior to vent, which rests in a depression anterior to anal fin. A minute, fleshy tubercle projects at each side of base of hood. Inner surface of the hood cleft in midline, enclosing a small compact papilla (?penis) which is followed by another median papilla.

TABLE 2. Selected Measurements and counts for *M. randalli*.

Character	Holotype		Paratypes			
	BPBM 17507		BPBM 18032	USNM 214112	USNM 214112	USNM 214703
Sex		♀			♀	♂
<i>Measurements</i>						
Standard length (SL)		mm	mm	mm	mm	mm
As % SL		%	%	%	%	%
Body depth at vent	42.6	6.8	16.0	4.1	15.6	5.7
Snout to dorsal fin	17.2	40.4	10.8	13.1	49.8	17.8
Snout to anal fin	21.3	50.0	13.1	17.8	49.7	15.0
Snout to ventral fin	8.5	19.9	5.5	7.3	20.4	7.9
Ventral fin length	—	—	4.2	16.0	16.2	4.8
Pectoral fin length	6.9	16.2	4.6	17.5	6.9	7.3
Pectoral fin base height	1.5	3.5	1.0	1.3	3.6	1.1
Head length (HL)	11.8	27.7	7.5	9.6	26.8	9.8
As % SL						
Orbit diameter, horizontal	1.4	11.9	1.0	13.3	15.6	1.6
Snout length	1.9	16.1	1.2	16.0	17.7	1.9
Jaw length	4.9	41.5	3.3	44.0	47.9	4.6
Interorbital width, least	1.1	9.3	0.7	9.3	7.3	0.8
Symphysis of cleithra to ventral fin	1.5	12.7	0.8	1.1	11.5	1.5
<i>Counts</i>						
Dorsal fin rays	86	—	—	84	83	81
Anal fin rays	74	—	—	71	76	71
Caudal fin rays	6	—	6	5	6	6
Vertebrae	12 + 44 = 56	12 + 43 = 55	12 + 43 = 55	12 + 43 = 55	12 + 43 = 55	12 + 41 = 53
Dorsal starts over centrum no.	10	11	10	10	10	10
Anal starts under centrum no.	16	16	15	15	17	15
Lateral scale rows	—	—	—	—	63	66

Study material: Microbrotula randalli. HOLOTYPE: Bernice P. Bishop Museum (BPBM) 17507, ♀ 35.8 mm SL, American Samoa, Tutuila, Fagafele Bay, 30–38 m, small caves in reef front at reef-sand interface, rotenone, collectors J. E. Randall, R. C. Wass and G. Yamasaki, 8 May 1974. PARATYPES: BPBM 18032 (1) and National Museum of Natural History (USNM) 214112 (2), data as for holotype; USNM 214703 (1), Efate (Vaté) Island, New Hebrides, Feb. 1974.

Microbrotula rubra. HOLOTYPE: USNM 162710, ♂ 36.2 mm SL. PARATYPES: BPBM 13760 (=UH 98), ♀ 45.2 mm SL; USNM 162711, ♀ 32.3 mm SL, stained and cleared specimen in glycerine.

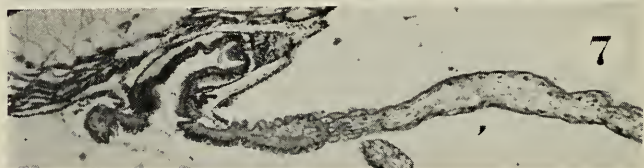
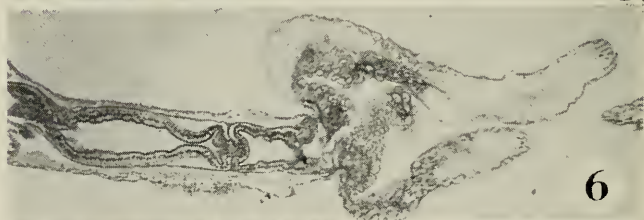
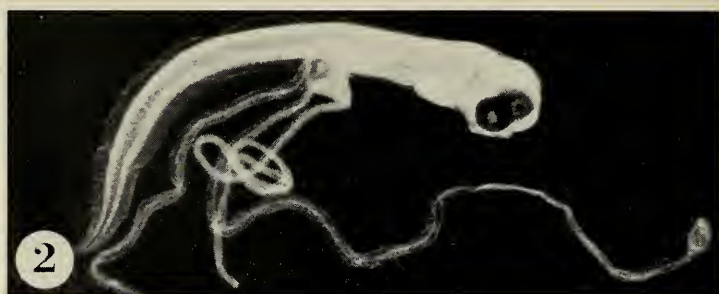
TROPHOTAENIAE AND EMBRYOS

Trophotaeniae are ribbon-like structures extending from the anal region of the embryos of several kinds of viviparous fishes. They were first described in goodeid fishes and subsequently have been found in the zoarcid genus *Parabrotula* and the ophidioid genus *Oligopus*. Descriptions of these structures in *Oligopus* and references to their occurrence are given by Wourms and Cohen (1975).

Four of the five known specimens of *Microbrotula randalli* are females. One of them is gravid and has several eyed embryos protruding, tail foremost, from the genital aperture, along with numerous tangled streamers of ribbon-like tissue. Other embryos can be seen through the body wall packed into both ovaries. Each embryo bears three elongate trophotaeniae which appear identical with structures described by Wourms and Cohen (1975) in *Oligopus longhursti*.

We have studied the gross anatomy and histology of embryos and trophotaeniae. Whole embryos, stained with methylene blue or alizarin, or unstained, were examined with reflected and transmitted light microscopy. Conventional methods were used for histology. Tissue sections, five micra in thickness, were stained with Mallory's triple stain or hematoxylin and eosin. Detailed methodology appears in Wourms and Cohen (1975).

Embryos: All embryos taken from the one gravid female were in the same stage of development. Embryos range from 3.5 to 4.0 mm. in total length (Fig. 2). They are mid-finfold embryos which correspond to stage 4 (finfold embryo) of *Dinematichthys ilucoeteoides* as described by Wourms and



Bayne (1973). Also, they are equivalent to stage 30–31 of *Fundulus* (Armstrong and Child, 1965). They are similar to other unspecialized teleost embryos at a comparable stage of development except for the presence of three long trophotaeniae which extend from the anal region (Fig. 2 and 3).

The dorsal and ventral fin folds have formed and extend around the caudal end of the embryo without interruption. The body of the embryo is straight except for a slight curvature in the caudal region. There is no protruding yolk mass. Sections through the slightly distended abdominal region re-

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FIG. 2. *M. randalli*, whole mount, glycerinated preparation of a 3.5 mm embryo; three trophotaeniae project from anal region; middle trophotaenia fully extended; each is considerably longer than the embryo. Darkfield optics; 20 \times .

FIG. 3. *M. randalli*, enlargement of anal region of embryo shown in fig. 2; on far right outline of gut appears on ventral surface of embryo ventral to a band of chromatophores; fleshy peduncle surrounds anus and gives rise to three trophotaeniae from anterior margin (somewhat distorted in this fig.); a refractile central core of connective tissue is present within each trophotaenia. Darkfield optics; 50 \times .

FIG. 4. *M. randalli*, isolated trophotaenial peduncle viewed from the ventral surface, posterior to the left, anus in the center; three trophotaeniae originate on anterior margin to the right, two are lateral, one is median; polygonal cells of the peduncle may be distinguished. Phase contrast; 80 \times .

FIG. 5. *M. randalli*, approximately saggital section through embryo, anterior to left; from left to right, brain, notochord and somatic muscles may be distinguished; ventral to these the gut (arrows) extends as a continuous tube from the mouth through the pharynx, foregut, hindgut and anus; trophotaenial peduncle extends fore and aft from the anus; transverse sections of trophotaeniae are present nearby. Brightfield; 100 \times .

FIG. 6. *M. randalli*, longitudinal section through lower ventral region, foregut to left, a prominent constriction separates fore and hindguts; hindgut opens through anus; trophotaeniae extend from both sides of peduncle-anal region. Brightfield; 100 \times .

FIG. 7. *M. randalli*, approximately saggital section of anal region, anterior to right; hindgut opens through anus; epithelial lining of hindgut is continuous with trophotaenial epithelium. Brightfield; 100 \times .

veal only a small amount of granular yolk material (Fig. 5). Far less yolk is present than in the embryos of *Oligopus* (Wourms and Cohen, 1975) and *Dinematichthys* (Wourms and Bayne, 1973) at similar stages of development.

The large, well-formed eyes are the most distinctive feature of the head. A lens is present. The choroid fissure is nearly obliterated. The retina is heavily pigmented and contains a reflecting layer. The neural retina consists of several well defined layers of cells. A nasal placode and the otic capsules have formed. There is a dorsal expansion of the mid-brain. Sections through the brain reveal both its considerable size and cellular complexity (Fig. 5). Pectoral fins are partially formed, and the pectoral girdle (cleithrum?) is a well ossified sliver of bone extending the entire depth of the embryo. Although ossified regions are present around the brain case and ethmoid, bone margins cannot be distinguished. The opercular flap has begun to form and is free. The lower jaw and gill arches have formed. Based on study of serial sections, the lower jaw is free and the mouth is open. Somatic muscles of the trunk and tail are organized into myomeres; striations can be distinguished in sections. The notochord is conspicuous both in whole mounts and sections. In addition, from sectioned material, one can identify the heart, liver, gall bladder (?), regions of the digestive tube, kidney, and ureter. The heart and larger blood vessels contain red blood cells.

Preserved embryos are a pale, translucent white color. A band of chromatophores originates behind the pectoral fin, extends to the anus, and then continues along the body above the ventral finfold. Pigment is scattered in the ventral finfold and in the rear part of the dorsal finfold and adjacent areas of the body. Also, a narrow line of chromatophores begins at the level of the trophotaenial peduncle and extends posteriorly in the lateral midline of the embryo.

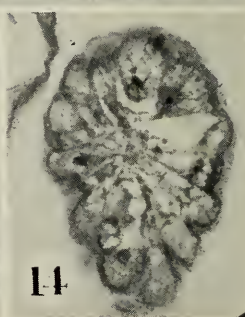
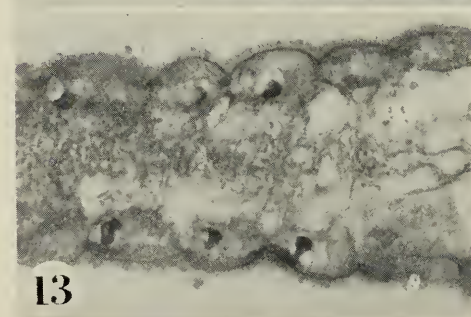
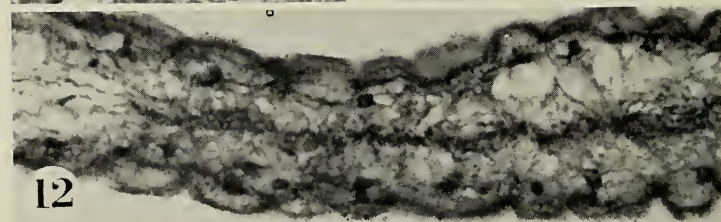
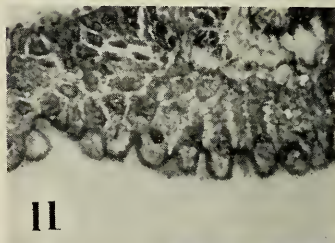
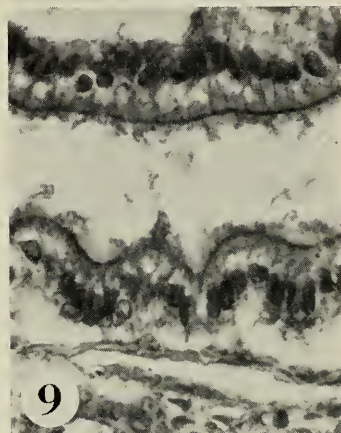
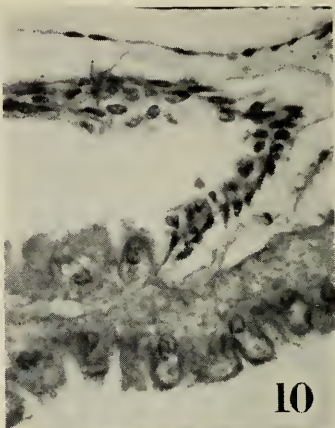
Gross morphology of the trophotaeniae: Three long processes, termed trophotaeniae, extend from the anal region of the embryo (Fig. 2). They occur in the form of a pair of anterior lateral processes and a single anterior median process (Fig. 4). Trophotaeniae originate from a conspicuous fleshy peduncle. The peduncle is a discoidal structure which resem-

bles an inverted mushroom cap; it consists of a central and a peripheral region. The central region surrounds the anus and is about 0.14 mm wide by 0.21 mm long; under favorable conditions, centripetal striations which give this area a sphincter-like appearance can be observed. Beyond the central region lies the peripheral region of the peduncle. Although in close proximity to the ventral surface of the embryo, it remains free along its dorsal, lateral, and ventral surfaces; the cells in this region are polygonal. The length of the entire peduncle, 0.42 mm, is equal to its width. The posterior margin of the peduncle forms a double crescent. The three trophotaeniae arise from its anterior margin (Fig. 4).

Trophotaeniae are free along their entire length except at their origin. All three processes are of approximately equal length and are longer than the embryo. In embryos of 3.4–4.0 mm. total length, the trophotaeniae are 5.0 to 6.0 mm. long. They are about 85–100 micra in diameter at their base and 40–55 micra in diameter at the tip. In shape, trophotaeniae are slender cylinders which may flatten into ellipsoidal ribbons (Fig. 5 and 14). With the aid of dark field optics, a refractile central core of connective tissue can be observed within each trophotaenia. In preserved specimens trophotaeniae are deciduous.

Histology of the gut and trophotaeniae: At this stage, the gut is a simple tube which is open at both ends. Beginning at the anterior end, one can distinguish seven regions: 1) mouth-oral cavity; 2) pharynx; 3) anterior portion of the foregut, above the liver and yolk mass (future stomach ?); 4) a constriction at which several ducts (pancreatic, bile ?) empty; 5) posterior portion of the foregut; 6) a well defined circular valve; and 7) the hindgut and anus (Figs. 5, 6, 8 and 9). To this may be added the trophotaenial peduncle and trophotaeniae which are gut tissues "outside" of the body.

The tubular gut is composed of a single layer of epithelial cells which rest on a thin basal lamina and a poorly developed investing layer of connective tissue. The mouth, pharynx, and anterior portion of the foregut are lined with a simple epithelium. The cells range in shape from flat squamous to



low cuboidal. They lack a striated border. No secretory cells have been observed.

The posterior portion of the foregut is separated from the hindgut by a well defined sphincter-like constriction (Figs. 6, 7, 8). The hindgut terminates at the anus where its cells form a gradual transition with those of the trophotaenial peduncle. Cells of the posterior foregut and the hindgut are identical. They are tall columnar epithelial cells which possess a well defined striated border (Figs. 8, 9). The cells are about 15 micra in height and 5 to 7 micra wide. Nuclei are about 3-4 micra in diameter. Occasional bits of debris are found in the lumen of the hindgut. In the region of the anus, there is a gradual and almost imperceptible transition from

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FIG. 8. *M. randalli*, approximately saggital section of hindgut, anus and trophotaenial peduncle, anterior to left. Brightfield; 200 \times .

FIG. 9. *M. randalli*, longitudinal sectional of gut, lumen in center, bounded by gut epithelium; free (apical) surface of gut cells have a well defined striated border. Brightfield; 820 \times .

FIG. 10. *M. randalli*, enlargement of area marked by arrow in fig. 8; note abrupt transition at junction between flattened, squamous cells of embryonic skin and large, dome-shaped cells of trophotaenial peduncle. Phase contrast; 820 \times .

FIG. 11. *M. randalli*, section through central region of trophotaenial peduncle, free (ventral) surface at bottom; dome-shaped cells bear microvilli on apical surface. Phase contrast; 615 \times .

FIG. 12. *M. randalli*, longitudinal section through a trophotaenia; a single layer of epithelial cells forms the outer surface; there is a prominent central core of connective tissue; tissue spaces extend between the core and surface epithelium. Brightfield; 500 \times .

FIG. 13. *M. randalli*, longitudinal section of a trophotaenia; surface epithelium composed of slightly flattened cuboidal cells; apical cell surface convex, with a well defined striated border formed of numerous microvilli; nuclei are basal; central core of connective tissue with many fibrils. Phase contrast; 820 \times .

FIG. 14. *M. randalli*, transverse section of trophotaenia; epithelial cells have a triangular profile; filaments or fibrils extend from basal surface toward central core; tissue spaces present between cells; microvilli of striated border are conspicuous. Phase contrast; 615 \times .

the cells of the hindgut to those of the peduncle. This is accomplished in part by a shift from a columnar epithelium to a cuboidal epithelium.

The trophotaenial peduncle is a fleshy disc of tissue which surrounds the anus. The anus opens in the central region of its ventral surface (Figs. 4, 8). In sections, the most conspicuous aspect of the peduncle is its papillose surface. This consists of cuboidal epithelium. The apical surface of each cell is highly convex, and there is a marginal cleft between apical portions of adjacent cells. This accounts for the knobby or papillose surface. The apical cell surface possesses a well defined striated border (Figs. 10, 11). Beneath the cells there is a thin basal lamina and a core of dense connective tissue. With the exception of the central region of the peduncle where connective tissue cells are abundant (Fig. 11), the underlying connective tissue contains few cells. Peduncle cells are larger than intestinal cells. They are about 20 micra high by 14 micra wide. Nuclei also seem larger, being 5-7 micra in diameter.

In addition to the anus-peduncle zone of transition, there are two other transition regions, peduncle to skin and peduncle to trophotaenia. There is a distinct zone of transition where the dorsal and lateral surfaces of the peduncle meet the embryonic skin on the ventral surface of the embryo (Fig. 10). The transition zone consists of about 10-15 cells. The embryonic skin is much flattened, squamous epithelium. Cells and cell nuclei are smaller than the peduncle cells. They lack a striated border. The transition from squamous skin cells to papillose peduncle cells involves a linear sequence of squamous cells whose apical surface becomes more dome shaped and whose height increases.

Peduncle cells seem to be giant cells. Their nuclear size raises the question of polyploidy, a state not uncommon in the cells of temporary structures. A second question concerns the papillose appearance of the peduncle epithelium. Is this the normal state of the living cell or does it represent a contraction induced by fixation? In passing, we note that, at the base of the peduncle, there are vacuolated cells as well

as profiles of structures which look like transverse sections of lacteals.

The final zone of transition is from the peduncle to the trophotaenia. The transition is gradual. Peduncle cells become reduced in height and flattened, losing their papillose appearance. Trophotaeniae consist of: an outer layer of epithelium; an interior core of connective tissue; and many secondary tissue spaces. The outer surface of the trophotaenia is formed by a continuous sheath of cells. It is simple epithelium in which all cells are morphologically identical. Cell shape is midway between that of a low cuboidal and a high squamous epithelium. Cells are 21–28 micra wide by 10–11 micra in height. The nucleus is about 3.5 micra in diameter. The apical cell surface is convex and bears a well defined striated border in which microvilli are readily distinguished. Nuclei occupy a basal position. A nucleolus is present. In tangential sections, boundaries between adjacent cells are well developed and stain intensely. The epithelial cell cytoplasm is intensely acidophilic. In transverse sections, epithelial cells appear conical (Fig. 14). The apex of the cell is wider than the base. A cytoplasmic process or fibril extends from the basal surface into the central region of the trophotaenia. The interior of the trophotaenia comprises: a dense mass of connective tissue with a central core of refractile connective tissue fibers (Figs. 2, 3, 12, 13); epithelial cell processes; and mesenchymal cells. Secondary tissue spaces are found between the basal regions of epithelial cells. They establish a series of compartments which lie between the external epithelial sheath and the central core (Figs. 12, 13). In transverse sections, the tissue spaces often tend to be radially arranged (Fig. 14). In some sections, there are structures which appear to be central blood vessels. They are associated with the central core of connective tissue fibrils.

FUNCTION AND SIGNIFICANCE OF TROPHOTAENIAE

Among viviparous ophidioid fishes trophotaeniae are known to occur only in embryos of *Oligopus longhursti* and *Microbrotula randalli*. In both species, trophotaeniae are of essentially identical structure.

Epithelial cells forming the outer surface of trophotaeniae are continuous with and identical to the epithelium which lines the "intestinal" portion of the embryonic gut. Minor organizational differences exist, viz., gut cells are columnar while trophotaenial cells form a low cuboidal epithelium. Both cell types, however, are identical. Moreover they have no structural similarity to the cells which comprise the embryonic integument. We suggest that the trophotaeniae of *Microbrotula* embryos function in the absorption of intra-ovarian nutrients of maternal origin. They are placental analogues. We attribute this function to the trophotaeniae as their epithelial cells are structurally identical to intestinal epithelial cells whose known function is the absorption of nutrients. The argument and its limitations are presented at length elsewhere (Wourms and Cohen, 1975). Moreover, in a study of goodeid embryos, Mendoza (1972) presented ultrastructural evidence of considerable pinocytotic activity in the trophotaenial epithelium, an observation which lends additional support to their role as an absorptive epithelium. The occurrence of trophotaeniae in embryos of most goodeid fishes, a zoarcid, and two ophidioids is a remarkable example of convergence in the evolution of embryonic adaptations (Wourms and Cohen, 1975).

In the only gravid female *M. randalli* which we were able to examine, we were surprised to find that it contained few embryos, and that each embryo possessed only a small amount of yolk. It is unlikely that these embryos were close to term, even though they were protruding from the genital aperture and had only a small amount of yolk left. They are not as well developed as full term *Dinematichthys* embryos (Wourms and Bayne, 1973) and probably would be incapable of feeding. Protrusion of embryos from the genital aperture is considered a preservation artifact. *Microbrotula* embryos probably continue to develop within the femal to a stage at least equivalent to full term *Dinematichthys* embryos. Considering the small amount of yolk which remains, it is obvious that trophotaeniae must play an important role in nourishing embryos of *Microbrotula*, at least those at a relatively advanced stage of development.

In addition to differing from *O. longhursti* by having less yolk in embryos which have not reached full term, *M. randalli* is surprisingly less fecund. One specimen of *Oligopus* (99 mm SL) carried an estimated 6500 eggs. In *Microbrotula*, Gosline noted 50 to 80 eggs in each ovary of a specimen of *M. rubra* (37.5 mm SL) for a total of 100 to 160, and we count a total of about 80 through the body wall of a cleared 32.3 mm specimen. We have not dissected the single gravid specimen of *M. randalli* noted above, but on the basis of observations through the thin body wall would estimate a fecundity of the same order of magnitude in both *Microbrotula* species. Even when size difference is compensated for by extrapolating to equivalent ovarian volumes, *Microbrotula* is still less fecund (an estimated 800–1300 embryos vs 6500).

It has been proposed that trophotaeniae in *Oligopus* serve to maximize the advantage of high fecundity (Wourms and Cohen, 1975). If the preceding is a valid assumption, then what function is served by trophotaeniae in low fecundity *Microbrotula*?

Although *Microbrotula* and *Oligopus* are taxonomically more closely related to each other than is either to the Goodeidae, the function of trophotaeniae in *Microbrotula* apparently more nearly resembles the function of trophotaeniae in goodeids. Both kinds of fishes have low fecundity and a relatively small supply of yolk, and it seems reasonable to propose that the "placental" function of trophotaeniae supplements an inadequate supply of nourishment in the yolk. Support is given this interpretation by the situation in the related *Dinematichthys*, a low fecundity viviparous species that lacks trophotaeniae and is well supplied with yolk (Wourms and Bayne, 1973).

Given the present meager knowledge on size of full term embryos, duration of gestation, and number and frequency of broods, the above hypothesis seems the most economical possible.

The occurrence of trophotaeniae appears to be capricious in nature, and to invoke convergent evolution is to describe, not explain. An interesting analogous situation, which regrettably deepens the mystery rather than suggesting an explana-

tion, concerns the occurrence of true spermatophores in vertebrates (Nielsen, Jespersen and Munk, 1968). These structures are found in certain salamanders, diverse elasmobranchs, one known cyprinodontoid fish (the group that includes Goodeidae) and a diverse group of viviparous ophidioid fishes. Furthermore, within the ophidioid genus *Calamopteryx*, two species have spermatophores while one does not (Nielsen in Cohen, 1973).

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